A NOTE ON A DICOTYLEDONOUS FOSSIL WOOD FROM ULLADULLA, NEW SOUTH WALES.

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(*From the Botanical Laboratories, University of Sydney.*)

(Plates v and vi, and six Text-figures.)

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Introduction.

The subject of this communication is a piece of fossil wood of a dicotyledon. It was found by Miss Brown of the Geology Department, University of Sydney, in a silica quarry at Bannister Head, near Ulladulla, New South Wales.

The author published a brief descriptive note of this fossil in connection with Miss Brown's paper on the Tertiary Formations on the South Coast of New South Wales.[2][1] It seems desirable that a fuller account of this interesting specimen, supplemented by figures and photographs, should be recorded in order that its systematic position may be ascertained.

Two fossil Angiosperm stems, with structure well preserved, have previously been described from Australia. Sahni[16] has published a description of two stems from the Tertiary of Queensland. One, *Petaloxylon scalariforme*, from Mt. Meershaum, near Nerang, is peculiar in that the chief conducting elements are large scalariform tracheids. The medullary rays are 1-3 seriate, twenty-five to thirty cells in height and pursue a sinuate radial course. The other, *Petaloxylon porosum*, has essentially the same structure except that true vessels are also present. Nobes[15] records the discovery of four petrified stems from some Tertiary Brown Coal deposits in South Australia. The preservation of these was so poor that no description was published.

A great number of leaf impressions have been described by Ettinghausen[5] and Deane.[3] [4] These remains, which have mostly been derived from Tertiary

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[1] The silica beds, in which the specimen was found, were formerly believed to be of Permo-Carboniferous age and the silicification was thought to have been effected by the intrusion of volcanic dykes (Harper).[8] [9] [10] Miss Brown[2] has lately proved that these strata are of Tertiary age and has shown on reliable geological evidence that silicification has been effected by later Tertiary basalts.

These "silica rocks" occur in patches, associated with clays and sandstones, in the Milton-Ulladulla district on the South Coast of New South Wales, overlying beds of Upper Marine age. At Bannister Head there is a slight angular unconformity between the later sediments and the underlying Permo-Carboniferous strata; and also at Pattimore's Lagoon deposit, as well as at Bannister Head, remnants of the basalt flows are evident in the form of capping sheets.

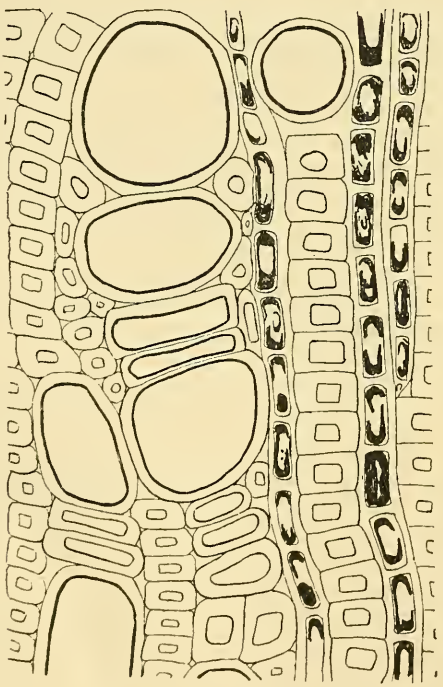
Petrographic studies by Miss Brown of the olivine basalt composing these lavas have established the correlation between the flows in this region and other Tertiary basalts of the State. Though the exact age of these "Tertiary Olivine Basalts" has not been definitely determined, it is generally held (Sussmilch)[20] that they belong to the Upper Miocene or Pliocene period. The deposition of the underlying silica beds must then be assigned to the Lower Tertiary Period.

deep leads, come from the same period as the Ulladulla fossil and give an indication of the Angiosperm flora existing at that time.

Ettinghausen has described fruits as well as leaf impressions of *Casuarina*, *Persoonia*, *Grevillea*, *Hakea*, *Lomatia*, *Dryandra*, *Callicoma*, *Ceratopetalum*, *Pomaderris*, *Eucalyptus*, *Santalum*, *Myrica*, *Quercus*, *Alnus*, *Acer*, *Aralia*, *Cinnamomum*, *Fagus* and *Elaeocarpus* from Vegetable Creek, near Emmaville, New South Wales. These, it will be observed, include many endemic genera as well as representatives of the Malayan flora.

The same author has described many types from Dalton, near Gunning, New South Wales. Deane[3] [4] has identified a number of leaf impressions from the clay beds at Mornington, Berwick, and Wonwron, Victoria; R. M. Johnston[11] [12] describes similar impressions from the Lower Tertiary of Tasmania.

These remains have, with few exceptions, all been referred to existing genera. In some cases the resemblance between fossil forms and living species is so close that the affinity has been expressed in the specific name given to the fossil. *Eucalyptus pre-coriacea* from the Lower Tertiary, for example, is almost identical with the existing species "*coriacea*." From this evidence it will be observed that the flora of the Lower Tertiary was very similar to that existing at present.



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Text-figure 1.—Representation of portion of the transverse section (slightly diagrammatic), showing the seriation of the vessels and fibres; illustrating particularly the thickness of the walls of the vessels and fibres. × 280.

Description.

Material. The specimen consists of a fragment of secondary wood preserved by the agency of silica. It measures roughly 8 cms. by 4 cms. The end, which is cut transversely, shows regular and well developed annual rings. The curvature of these indicate that the piece of wood was about two and a half inches from the centre of the stem and that the stem had a minimum diameter of five inches. The structure of the wood is well preserved. Unfortunately the specimen does not show any phloem or bark.

Microscopic Description.

Diagnosis: The wood has a fine texture. Annual rings developed. *Vessels* numerous, circular, in radial series or isolated; bordered or scalariform pitting, mostly porous perforate, tertiary bands present, slightly stratified, average diameter 0·1 to 0·075 mm.; average of 50 per sq. mm. *Wood fibres* form the ground tissue of xylem, thick walled, size variable, arranged in regular radial series. *Wood parenchyma* cells abundant, rectangular, vertical height, 0·04 mm., width 0·25, occurring in vertical series. *Medullary rays* numerous, diffuse, biseriate, rarely uniseriate, 10-15 cells in height, heterogeneous, cell walls thick with simple oval or circular pits.

General: The vessels are of medium size and are evenly distributed throughout the wood. The wood fibres compose the bulk of the wood and are very thick walled. The vessels in the spring have a diameter up to 0·16 mm. These become gradually smaller till at the end of the annual ring in the autumn the average diameter is 0·04 mm. Parenchyma cells are abundant, diffuse and mostly situated at the end of the annual rings, almost forming metatracheal bands. The medullary rays are very uniform in height. The vessels and wood fibres are arranged in regular radial series.

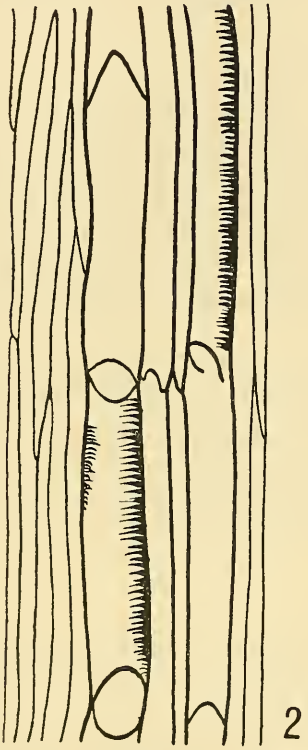
Details of Elements:

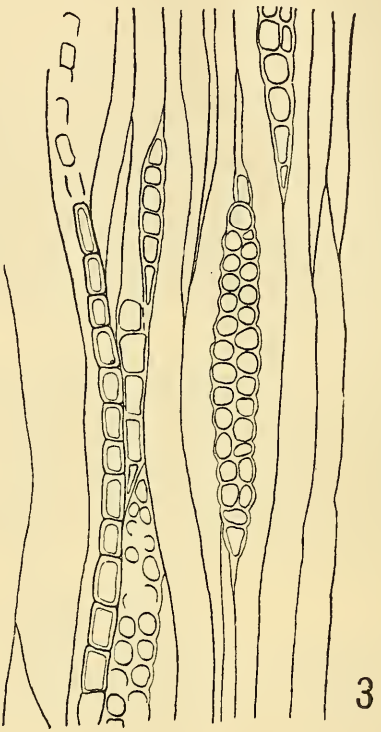
In transverse section the *Vessels* show an approximately circular configuration. They occur singly or in pairs or in radial rows up to ten in number. In these latter cases the tangential walls are flattened (Text-fig. 1 and at *b* in Fig. 1, Plate v). The average diameter is 0·075 mm. The average diameter of the spring elements is 0·13 mm. and the autumn average is 0·05 mm. The walls are thick. In longitudinal section the sculpturing on the walls consists of regular series of small oval bordered pits in horizontal rows (Text-fig. 4*c* and Fig. 2, Plate v). The borders of the pits are narrow.

The large vessel in the centre of Fig. 2 Plate v shows this type of pitting very well. In some cases the coalescing of the pits gives rise to a close scalariform sculpture. This feature is apparent in the large vessels in Fig. 3 Plate vi and appears, in fact, to be the dominant type. The internal spiral bands of thickening, termed tertiary thickenings, are also present in many of the vessels.

The average length of the vessel segments is 0·6 mm. The two segments, illustrated in Fig. 3 Plate vi, are typical and each of these has a length of 0·6 mm. The majority are of the porous end-wall type (Text-figs. 4*c* and 6 and Fig. 2 Plate v and Fig. 3 Plate vi). The septa in these elements are short and distinct; they are almost at right angles to the longitudinal walls of the vessel. Each is perforated by one large pore. A few vessels exhibit a number of elongated pores on the end-wall. These are examples of the scalariform perforate type. In some

cases the so-called "imperfect perforation" is present. The end-walls in vessels, which show this feature, are very oblique and numbers of bordered pits occur on them together with one or two large perforations (Text-fig. 4 *a* and *b*). Vessels with end-walls of this nature are longer and have a smaller diameter than the neighbouring vessels with the porous type. No tyloses were observed. The vessels appear to be more or less stratified or storied.





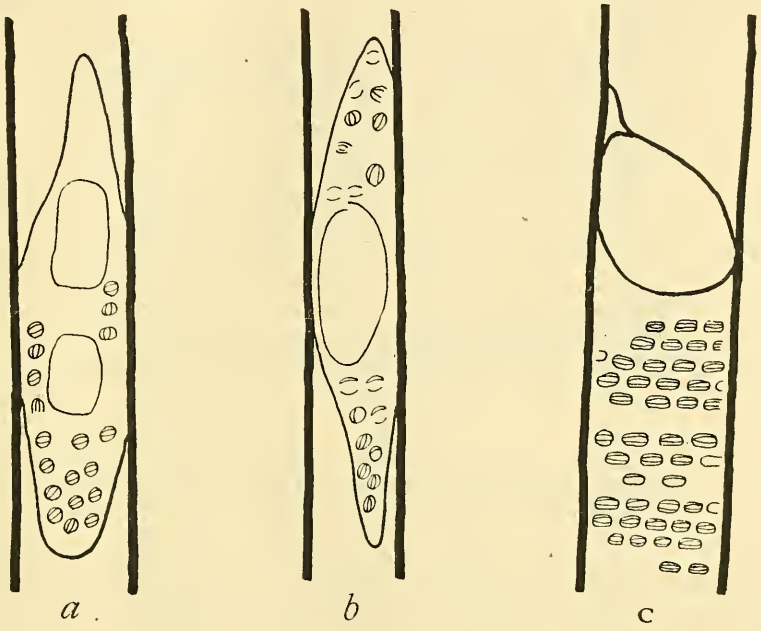
Text-figure 2.—Representation of portion of the radial longitudinal section showing the vessels in detail. An indication of a close scalariform sculpturing is apparent on the lateral walls of several porous end-wall types of vessels. × 80.

Text-figure 3 represents a portion of the tangential longitudinal section showing the medullary rays in detail together with vessels and fibres. On the left there is a series of parenchyma cells with the original thickness of the walls preserved. × 165.

The *wood fibres* vary considerably in diameter and length. The average diameter is 0·02 mm.-0·01 mm. Very often the tangential diameter is greater than the radial. In general the walls seem thin (Text-fig. 2), but this appearance is due to the fact that it is really the junction line between contiguous fibres which represents the wall. In places where the preservation of the structure is more perfect and the true thickness of the wall is shown it presents a very characteristic appearance. The nature of the fibres is seen at *a* in Fig. 1 Plate v. The lumen

represents only one-third or one-fourth of the diameter. No pitting could be observed in the longitudinal aspects of these elements. They are regularly seriated in a radial direction.

The *wood parenchyma* cells are seen to best advantage in the longitudinal sections (Text-figs. 3, 4 and 5 and Fig. 3 Plate vi). They occur in vertical series and are most abundant in the region of the autumn wood. There are as many as forty cells in one series. The average vertical height of each cell is 0·040 mm. and the average width in tangential and radial aspect is 0·025 mm. The pitting on these cells was not observed. The walls are comparatively thick. In some instances black carbonaceous material is apparent in the cell cavity.



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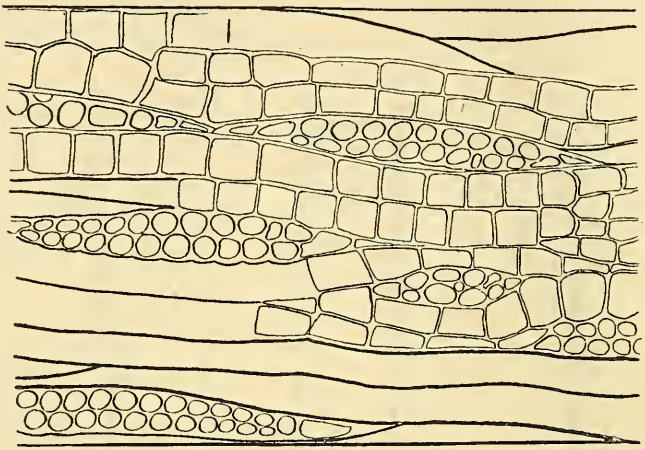
Text-figure 4.—Illustrating the types of end-wall found in the vessels in radial longitudinal section. In *a* and *b* the end wall is of the imperfect perforate type. At *c* is shown a typical porous perforation in a vessel, which shows multiseriate pitting on the vertical wall. × 280.

The *medullary rays* are numerous and diffuse, heterogeneous and without exception uniseriate or biseriate. The vertical height of the ray is also a definitely characteristic feature. They are relatively short. The biseriate type of ray is predominant and in tangential section generally contains 20 to 30 cells (Text-figs. 3 and 5 and Fig. 4 Plate vi). These rays are therefore about 10 and 15 cells in height. The two rows of cells, comprising the width of the ray in tangential view, alternate. The uniformity of the width of the ray is one of the most interesting features of the stem. The individual cells have a vertical height of 0·02 mm. and are approximately 0·07 mm. in radial length (Text-fig. 6). In

tangential view they appear rounded with an average diameter of 0·02 mm. A large amount of black carbonaceous matter is present in the cell cavity (Fig. 4 Plate vi). In places the pits on the walls of these cells may be distinguished in the radial longitudinal section. They are more or less rounded and simple. The walls of the ray cells contiguous to other ray cells are thick and are pitted in the same manner. These pits could be observed in section as well as in surface view (Text-fig. 6).



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Text-figure 5.—Representation of portion of the tangential longitudinal section of the autumn wood showing an abundance of wood parenchyma series. × 165.

Systematic Position.

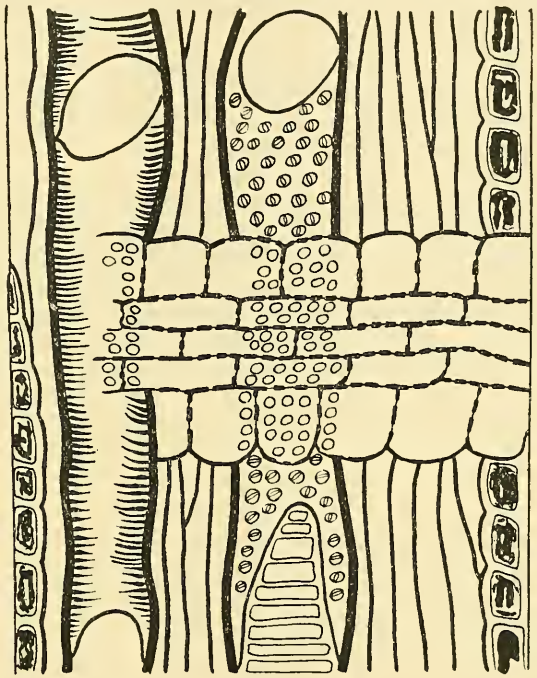
Our knowledge, at present, of the systematic anatomy of the dicotyledonous stem is meagre. On this account the affinities of a fossil stem may be satisfactorily determined, only when very distinctive features are observed.

Fliche,[7] Lignier,[14] Stopes and Fujii,[18] Stopes,[19] Krausel,[13] Bailey,[1] and Edwards,[6] have described dicotyledonous stems from the Cretaceous and Tertiary in other parts of the world. Each of these authors has named the fossils described, after the woods of the living genera, which they most closely resemble. In this way the affinities of the specimens have been indicated. In the case of the Ulladulla fossil it has been found that the structure indicates an affinity with a certain Natural Order and not with one particular genus. There is a very close resemblance between the woods of the various genera of this Natural Order. On this account it is not possible to select one genus, which has a preeminent affinity with the fossil. The writer therefore has not followed the precedent established by the authors quoted above, but deems it wisest only to indicate the apparent systematic position of the specimen.

The characters of every Order upon which information is available[17] have been carefully considered. Representatives of certain orders show similarities to the fossil but differ in important details. Types of the Schizandreae group of the Magnoliaceae, for example, possess a very similar combination of wood structures,

but differ in the fact that the medullary rays characteristically have a great vertical height. Certain genera of the Natural Orders Bixineae, Euphorbiaceae, Anarcardiaceae, and Rutaceae have somewhat similarly constituted woods. These particular genera, however, are not represented in the present-day Australian flora. As a most striking resemblance is evident between the wood of the fossil and the woods of an Order, which is widely distributed in Australia, it seems that the similarities referred to above may be disregarded.

The writer has examined figures, descriptions or actual sections of representative woods of most of the natural orders found in Australia. The Saxifragaceae alone possess the same type of wood structure as that exhibited by the fossil. The combination of wood structures, which are characteristic of this



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Text-figure 6.—Diagrammatic representation of a radial longitudinal section. All the features depicted may be clearly observed in certain places in the sections. The heterogeneous nature of the medullary ray is shown and the nature of the pitting on the various elements. × 280 approx.

order, seems to be identical with the combination of structures present in the fossil. The regular radial seriation of the vessels, the occurrence of scalariform perforate end-walls in the vessels, as well as the narrow, heterogeneous, and uniform medullary rays are characteristic features of the woody genera of this order. For these reasons the writer tentatively places the Ulladulla specimen in the Natural Order Saxifragaceae.

I am indebted to Mr. Welch, of the Technological Museum, for allowing me to examine photo-micrographs of the woods of certain representatives of this order,

which I could not easily obtain in the living state. *Weinmannia, Ackmana, Schizomeria, Quintinnia, Callicoma,* and *Ceratopetalum* show a remarkable resemblance to the fossil. In the case of *Ackmana* the structures were almost identical.

In conclusion, I wish to thank Professor A. A. Lawson for advice in the preparation of the text, and Mr. Welch for the above-mentioned assistance. I am indebted also to Dr. Carl Boesen and Mr. R. Murray, B.Sc., for the photo-micrographs reproduced.

Summary.

1. The specimen described was obtained from the "Silica" beds at Bannister Head, near Ulladulla, on the South Coast of New South Wales. These beds are of Lower Tertiary age.

2. The specimen is a piece of silicified secondary wood.

3. The structure of the wood is that of a typical dicotyledon, and shows a very close agreement with that of the Natural Order Saxifragaceae. The author tentatively places the specimen in this Order.

I have endeavoured to represent the nature of the individual elements accurately though a certain latitude has been taken in making the drawings. In Text-fig. 2, for instance, the medullary rays have been omitted in this radial longitudinal representation in order that the vessels may be seen more clearly. Further a uniform state of preservation is not present throughout the specimen; and irregularities in preservation render it impossible to depict the true character of all the elements in a drawing with the camera lucida. The less obvious details of structure in the various elements may not all be observed in one place in the section. For these reasons it was thought advisable to draw together features which could be definitely recognized into two diagrammatic figures (Text-figs. 1 and 6).

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EXPLANATION OF PLATES V and VI.

Plate v.

1. Photo-micrographic representation of portion of the transverse section. The vessels are clearly seen and in places the wood fibres are visible. Fibres are well shown at *a*. The cellular structure of the numerous and narrow medullary rays is not distinguishable. These cells are filled with carbonaceous material. × 200.
2. Photo-micrographic representation of radial longitudinal section. The principal feature is a large vessel showing a large terminal porous perforation and multiseriate pitting on the lateral wall. The wood fibres may be seen and also indications of the medullary rays, which are poorly preserved in this portion of the stem. × 200.

Plate vi.

3. Photo-micrographic representation of a radial longitudinal aspect showing two large vessels with porous perforations. Medullary rays are seen crossing the vessels. On the lateral walls of the vessels portions of the scalariform type of sculpturing are discernible. × 200.
4. Photo-micrographic representation of the tangential longitudinal section. This shows the medullary rays. At *a* a series of wood parenchyma is evident. × 200.